Rayat Shikshan Sanstha's

Yashavantrao Chavan Institute of Science, Satara (Autonomous)

Lead College of

Karmaveer Bhaurao Patil University, Satara

Post-graduate Programme

M. Sc. II

Statistics

Syllabi of the course as per NEP - 2020

Choice-based credit system syllabus

(To be implemented from the academic year 2024-25)

Preamble

The goal of syllabus to make the study of Statistics popular and interesting among the students for job achievements as well as higher studies.

The syllabus is prepared after discussion at length with number of faculty members of the subject and experts from industries and research fields. The units of the syllabus are well defined, taking into consideration the level and capacity of students.

Course Structure M.Sc. Part II

M.Sc. II (Statistics) Semester – III

Level	Semester	Course Code	Course Title	No. of Lectures Per Week	Credits
	Discipline Specific Courses (Mandatory)				
6.5	III	MST 531	Asymptotic Inference	4	4
		MST 532	Clinical Trial	4	4
		MST 533	Multivariate Analysis	4	4
		Discipline Specific Elective (Choose Any one among two)			
		MST 534 E-I MST 534 E-II	E-I Survival Analysis E-II Data Mining	2	2
		MSP 535	Research Project	12	6
		MSP 536	Practical Lab III (based on MSt-531,532, 533,534	4	2
Total					**22**

M.Sc. II (Statistics) Semester – IV

Level	Semester	Course Code	Course Title	No. of Lectures Per Week	Credits
	Discipline Specific Courses (Mandatory)				
6.5	IV	MST 541	Time Series Analysis	4	4
		MST 542	Stochastic Process	4	4
		MST 543	Advanced Optimization Techniques	4	4
		Discipline Specific Elective (Choose Any one among two)			
		MST 544 E-I MST 544 E-II	E-I Planning and Analysis of Industrial Experiments E-II Actuarial Statistics	2	4
		MSP 545	On Job Training (OJT)	8	4
		MSP 546	Practical Lab IV (based on MST-541,542, 543,544	4	2
Total					**22**

Semester III

MST 531: ASYMPTOTIC INFERENCE

Course Objective: Student will able to

1. Understand the basic idea of consistency of an estimator.
2. Develop generalization aspect of inferential theory.
3. Learn the methods of constructing consistent estimators, Method of Moments.
4. Study the theories and methods of asymptotic inference.

Credit = 4	**MST 531:ASYMPTOTIC INFERENCE**	**No. of hours: 60**
Unit I	**Consistent estimator and CAN estimator**	**15**
	1.1 Review of Consistency of an estimator, weak and strong consistency, joint and marginal consistency, invariance property under continuous transformations, methods of constructing consistent estimators, asymptotic relative efficiency. 1.2 Consistent and Asymptotic Normal (CAN) Estimators: Definition of CAN estimator for real and vector valued parameters, invariance of CAN property under non-vanishing differentiable transformation. 1.3 Methods of constructing CAN estimators: Method of Moments, method of percentiles, comparison of CAN estimators.	
Unit II	**CAN and BAN estimator**	**15**
	2.1 BAN estimators, CAN and BAN estimators in one parameter and multi-parameter exponential family of distributions, super-efficient estimators, Crammer regularity conditions, Cramer – Huzurbazar results. 2.2 Sheffe's theorem, Polya's theorem and Slutsky's theorem.	
Unit III	**Variance stabilizing Transformation**	**15**
	3.1 Variance stabilizing transformations; their existence; their applications in obtaining large sample tests and estimators. 3.2 Asymptotic Confidence Intervals based on CAN estimators and based on VST, Asymptotic distribution of function of sample moments. 3.3 Asymptotic Confidence regions in multi-parameter families. 3.4 Gauss-Legendre-Boscovich Revisited, unbiased confidence intervals.	
Unit IV	**LRT and Non parametric Inference**	**15**
	4.1 Likelihood ratio test and its asymptotic distribution, Wald test, Rao's Score test, Pearson Chi- square test for goodness of fit, Bartlett's test for homogeneity of variances, Levens test. 4.2 Consistent test, comparison of tests: asymptotic relative efficiency of tests (Pitman and Bahadur efficiency). 4.3 Nonparametric Inference, U-Statistics, Some Single-Sample problems, Some Two-Sample problems, Test of Independence.	

Course Outcomes: Students should able to

1. Distinguish between weak and strong consistency, joint and marginal consistency
2. Understand the concept of CAN and BAN estimators, their related results.
3. Learn the concept of super-efficient estimator, variance stabilizing transformation and their application in large sample test.
4. Obtain the asymptotic confidence interval based on CAN and VST.

References:

1. *Kale B.K.,* A first course on parametric inference, Narosa Publications, (1999)
2. *Zacks S.*, Theory of statistical inference, Wiley & Sons inc., (1971)
3. *Rohatagi V. K. and Saleh A. K. Md. E.,* Introduction to Probability Theory and Mathematical Statistics, John Wiley and sons Inc., (2001)
4. *Ferguson T.S.,* A Course in Large Sample Theory, Chapman and Hall (1996)
5. *Lehmann E. L.,* Elements of Large Sample Theory, Springer, (1999)
6. *Das G. A.,* Asymptotic Theory of Statistics and Probability, Springer Texts in Statistics., (2008)
7. *Srivastava M. K., Khan A. H. , Srivastava N.,* Statistical Inference, PHI learning Pvt. Ltd, (2014)

MST 532: CLINICAL TRIALS

Course Objectives: Student will able to

1. Understand fundamentals of clinical trials in order to deepen the understanding of clinical trials thatare very important part of the any medicine.
2. Learn and develop scientific view to study the statistical challenges of clinical comparison of two ormore treatments in human subjects.
3. Aware of the use of the cross-over design and its limitations.
4. Develop the skills to analyses the clinical trial data.

Credit = 4	**MST 532:CLINICAL TRAILS**	**No. of hours: 60**
Unit I	**Fundamentals of Clinical Trials**	**15**
	1.1 Introduction to clinical trials: the need and ethics of clinical trials, bias and random error in clinical studies, conduct of clinical trials, overview of Phase I-IV trials, multi-center trials. 1.2 Data management: data definitions, case report forms, database design, data collection systems for good clinical practice, Concept of Randomization and blinding.	
Unit II	**Design of clinical trials**	**15**
	2.1 Design of clinical trials: parallel vs. cross-over designs, cross-sectional vs. 2.2 Longitudinal designs, review of factorial designs, objectives and endpoints of clinical trials. 2.3 International Conference on Harmonization (ICH), Brief history of ICH, Structure of ICH Harmonization Process, Guidelines for Good Clinical	

	Practice Glossary, The Principles of ICH GCP, Institutional Review Board / Independent Ethics Committee, Introduction of E9 and E6 Guideline. 2.4 Concept of Clinical Trial Protocol and Statistical Analysis Plan (SAP).	
Unit III	**Bioequivalence Trials**	**15**
	3.1 Concept of Pharmacokinetics parameters, Design of bioequivalence trials, Classical methods of interval hypothesis, testing for bioequivalence Baysian methods, nonparametric methods. 3.2 Assessment of inter and intra subject variability, drug interaction study, Dose proportionality steady state analysis, Clinical end points, alpha spending function. 3.3 Advances in Clinical trial analysis. Introduction to Clinical Trials on Implants.	
Unit IV	**Analysis and Reporting of Clinical Trials**	**15**
	4.1 Analysis and reporting of clinical trials: Concept of sample size and it's calculation. 4.2Analysis of categorical outcomes from Phase I - III trials, analysis of survival data from clinical trials	

Course Outcomes: Students should able to

1. Understand need and ethics of any clinical trial and how to conduct clinical trial of any medicine indifferent phases.
2. Apply various designs of clinical trials to the data.
3. Understand the designs of clinical trials.
4. Analyse and report the clinical trials.

References:

1. *Piantadosi S.*, Clinical Trials: A Methodologic Perspective (Wiley and Sons,1997)
2. *Shein C. C. and Liu J. P.*, Design and analysis of clinical trials: Concept and Methodologies,Wiley Series in probability and statistics (second edition), (2000)
3. *Jennison C. and Turnbull B. W.,* Group Sequential Methods with Applications to Clinical Trials, CRCPress.,(1999)
4. *Friedman L. M., Furburg C., Demets D.*, Fundamentals of Clinical Trials, Springer Verlag., (1998)
5. *Fleiss J. L.*, The Design and Analysis of Clinical Experiments (Wiley and Sons., 1989)
6. *Durham T. A. & Turner J. R.,* Introduction to Statistics in Pharmaceutical Clinical Trials, Pharmaceutical Press, (2008).

MST 533: MULTIVARIATE ANALYSIS

Course Objectives: Student will able to

1. Learn and develop scientific view to deal with multidimensional datasets and its uses in the analysisof research data.
2. Understand the extensions of univariate techniques to multivariate frameworks.
3. Apply dimension reduction techniques used for data analysis.
4. Construct group of similar objects with respect to some characters by hierarchical and non-hierarchical way.

Credit = 4	MST 533: MULTIVARIATE ANALYSIS	No. of hours: 60
Unit I	**Multivariate normal distribution**	**15**
	1.1 Exploratory multivariate data analysis, sample mean vector, sample dispersion matrix, correlation matrix, graphical representation, means, variances, covariances, Partial and multiple correlation coefficients. 1.2 Correlations of linear transforms. Multivariate normal distribution, two definitions and their equivalence, singular and nonsingular normal distribution, characteristic function, moments, marginal and conditional distributions. 1.3 Maximum likelihood estimators of the parameters of the multivariate normal distribution and their sampling distributions.	
Unit II	**Hotelling's T^2 Statistic and Wish distribution**	**15**
	2.1 Hotelling's T^2 Statistic and its null distribution. Applications of T^2 statistics and its relationship with Mahalanobis' D2 statistic. 2.2 Goodness of fit of multivariate normal distribution, Confidence region for the mean vector, and Tests of significance for multiple and partial correlation coefficients. 2.3 Wishart matrix and its distribution, properties of Wishart distribution, distribution of generalized variance.	
Unit III	**Principal Component Analysis and Factor Analysis**	**15**
	3.1 Principal Component Analysis 3.2 Factor Analysis Underlying Models and Illustrations, Identification Problem, Estimation – Maximum likelihood Method, Centroid Method. 3.3Canonical Correlation – Extraction - Properties.	
Unit IV	**Discriminant Analysis and Clustering**	**15**
	4.1 Classification Analysis using Discriminant functions, Fisher's discriminant function, minimum ECM rule, classification with three populations. 4.2 Clustering techniques Hierarchical Clustering - Agglomerative techniques, Single Linkage Method, Complete average linkage method, Non-hierarchical method–K-Mean. 4.3 Methods and applications of MANOVA (without derivation of the distribution of Wilks' lambda)	

Course Outcomes: Students should be able to

1. Understand the multivariate normal distribution and their real-life applications.
2. Understand Wishart distribution, Hotelling T2 and Mahalanobis D2 statistic.
3. Implement dimension reduction techniques using software on real-life problems.
4. Demonstrate knowledge of the basic ideas behind discriminant and clustering analysis techniques with applications.

References:

1. *Anderson T. W.*, An Introduction to Multivariate Statistical Analysis, Second Edition, Wiley Eastern, (1980).
2. *Johnson R. A. and Wichern D. W.*, Applied Multivariate Statistical, 5th Edition, Upper Saddle River, NJ: Prentice hall, (2002).
3. *Jambu M. and Lebeaux M. O.*, Cluster Analysis and Data Analysis, North Holland Publishing Company, (1983).
4. *Kshirsagar A. M.*, Multivariate Analysis, Marcel Decker, (1972).
5. *Härdle, W. K. & Simar, L.*, Applied Multivariate Statistical Analysis, Springer, New York (2012).
6. *Morrison D. F.*, Multivariate Statistical Methods, Second Edition, McGraw Hill, (1976).

MST 534: SURVIVAL ANALYSES

Course Objective: Student will able to

1. Provide students the ability to sharpen the skills necessary to collect, handle and analyse the lifetimedata.
2. Learn the reliability theory and analysis of survival data.
3. Distinguish censored and uncensored data.
4. Visualize and communicate time-to-event data, to fit and interpret failure time model.

Credits =2	**MST 534: SURVIVAL ANALYSES**	**No. of hours: 60**
UNIT I	**Estimating the survival function**	15
	1.1 Various types of censoring: right, left, interval Censoring; random censoring; Survivor, hazard and cumulative hazard functions. 1.2 Estimating the survivor function: Life-table estimate, Kaplan-Meier estimate, Nelson-Aalen estimate; Standard error of the estimated survivor functions; Confidence intervals for values of the survivor function; Estimating thehazard function; Estimating the cumulative hazard function; Estimating the median and percentiles of survival times; Confidence intervals for the median and Percentiles.	
UNIT II	**The Cox regression model**	15
	2.1 A regression model for the comparison of twogroups; The general proportional hazards model, Models corresponding to the linear component of the model: including a variate, a factor, an interaction, a mixed term. 2.2 Fitting the Cox regression model in R, Likelihood function for the model, Treatment of ties, Confidence intervals and hypothesis tests for coefficients and for hazard ratios using R; Measures of explained variation, Measures of predictive ability. 2.3 Model checking using various types of residuals: Cox-Snell; Modified Cox Snell; Martingale; Deviance; Schoenfeld; Score residuals, plots based on these residuals and their interpretation.	

Course Outcomes: Students should able to

1. Collect the life time data using different methods of censoring.
2. Apply the Cox regression model

References::

1. *Barlow R. E. & Proschann F.*, Mathematical Theory of Reliability (John Wiley & Sons, Inc.,1965)
2. *Deshpande J. V. and Purohit S.G.* Life Time Data: Statistical Models and Methods (World scientificpublishing, 2005)
3. *Lawless J. F.,* Statistical Models and Methods of Failure Time Data, John Wiley.,(1982)
4. *Miller R. G.,* Survival Analysis, John Wiley and Sons., (1981)
5. *Bain L. O.*, Statistical Analysis of Reliability and Life Testing Models, Marcel Dekker,(1978)
6. *Nelson W.*, Applied Life Data Analysis, Jhon Wiley and Sons Inc.,(1982)
7. *Medhi J.*, Stochastic Processes (Second edition) New Age Science Ltd., (1994)

MST 534: DATA MINING

Course Objectives: Student will able to

1. The course aims to develop the skills necessary to handle and analyse the big and complex data tosolve the problems.
2. The concept of data mining for enterprise data management and as a cutting edge technology tool.
3. Enable to identify data sources, processing and imparting knowledge tools to analyze sets of data to gain usefulbusiness understanding.
4. Understand unsupervised learning and supervised learning techniques for univariate and multivariate data.

Credits=4	**MST 534: DATA MINING**	**No. of hours: 60**
Unit I	**Classification and Discriminant Analysis**	**15**
	1.1 Basic data mining tasks, Introduction to databases, including simple relational databases, data warehouses and introduction to online analytical data processing 1.2 Classification and decision trees, clustering methods from both statistical and data mining viewpoints, vector quantization. 1.3 Data understanding and data cleaning, concept of supervised and unsupervised learning. 1.4 Problem of classification, classification techniques: k-nearest neighbor, decision tree, Naïve Bayesian, classification based on logistic regression, Bayesian belief Network. 1.5 CART (classification and regression trees), Discriminant Classification.	
Unit II	**Model evaluation Classification Accuracy**	**15**

	2.1 Model evaluation and selection: Metrics for Evaluating Classifier Performance, Holdout Method and Random Subsampling, Cross-Validation, Bootstrap, Model Selection Using Statistical Tests of Significance, Comparing Classifiers Based on Cost–Benefit and ROC Curves. 2.2 Techniques to Improve Classification Accuracy: Introduction to Ensemble Methods, Bagging, Boosting and Ada Boost, Random Forests, Improving Classification Accuracy of Class-Imbalanced Data.	

Course Objectives: Student will able to

1. The course aims to develop the skills necessary to handle and analyse the big and complex data to solve the problems.
2. The concept of data mining for enterprise data management and as a cutting edge technology tool.
3. Enable to identify data sources, processing and imparting knowledge tools to analyze sets of data to gain useful business understanding.
4. Understand unsupervised learning and supervised learning techniques for univariate and multivariate data

References:

1) A.Borson and S.J.Smith (1997): Data Ware Housing, Data Mining and OLAP, McGraw Hill.
2) Breiman, J.H.Friedman, R.A.Olsher and C.J.Stone (1984): Classification and Regression Trees, Wordsworth & Brooks/Cole.
3) J.Han and M.Kamber (2000): Data Mining Concepts and Techniques, Morgan Gaufmann.
4) T.M. Mitchell (1997): Machine Learning McGraw Hill.
5) P.Naughton (1996): The Java Handbook, Tata McGraw Hill.
6) W.J.Savich (2001): Problem Solving with C++: The Object of Programming (3" Edn.) Addison Wesley, Longman.

MSP 535: Research Project (6 Credits)

Students will undertake research in specific area of his Major/Core with an advisory supported by a teacher/faculty member. Students are required to take 6 credit Research Project for semester III under the guidance of faculty members.

MSP 536: PRACTICAL LAB-III

Course Objective: Student will able to

1. Understand and implement theory in real life problems.
2. Apply inferential statistical techniques to solve real life problems.
3. Data handling by using data mining's techniques.
4. Data analysis and application of Multivariate analysis.

Credits=2	MSP 536: PRACTICAL LAB-III	No. of hours: 60
	1. Construction of Consistent Estimators. 2. Construction of CAN Estimators. 3. Construction of BAN Estimators and confidence interval based on it. 4. Confidence interval based on CAN. 5. Confidence interval based on VST. 6. Multivariate Normal Distribution 7. Application of Hotelling's T^2 statistics 8. Discriminant Analysis 9. Principle component analysis 10. FactorAnalysis. 11. Canonical Correlation 12. Pharmokinetics. 13. Confidence interval. 14. Analysis of categorical outcomes. 15. Parametric test based on Clinical Trials 16. Non-parametric test based on Clinical Trials 17. Survival Analysis of Clinical Trails. 18. Cluster Analysis. 19. Artificial Neural Network. 20. Support Vector Machine.	

Course Outcomes: Students should able to understand

1. Construction of Estimators and obtaining confidence interval.
2. Estimation of Survival Function and parameters.
3. Discriminant Analysis, PCA and Factor Analysis.
4. Data analysis and Non-parametric test based on Clinical Trials.

References:

1. B. K. Kale, A first course on parametric inference (Narosa Pub.,1999)
2. R. G. Miller, Survival Analysis (John Wiley and Sons., 1981)
3. D. C. Montgomery, E. A. Peck and G. G. Vining, Introduction to Linear RegressionAnalysis (Wiley, 2003)
4. Berson and S. J. Smith, Data warehousing, Data Mining, and OLAP (McGraw- Hill.,1997)
5. S. Piantadosi, Clinical Trials: A Methodologic Perspective (Wiley and Sons,1997)

SEMESTER-IV

MST 541: TIME SERIES ANALYSIS

Course Objective: Student will able to

1. Develop the necessary skills to identify the nature of the phenomenon represented by the sequence ofobservations and forecasting future values.
2. Learn and develop scientific view to understand the time series data and its analysis.
3. Learn stationary and non-stationary, and seasonal and non-seasonal time series models.
4. Learn to estimate model parameters and compare different models developed for the same dataset interms of their estimation and prediction accuracy.

Credits=4	**MST 541: TIME SERIES ANALYSIS**	**No. of hours: 60**
Unit I	**Exploratory time series analysis**	**15**
	1.1 Tests for trend and seasonality. 1.2Exponential and moving average smoothing. Holt-Winters smoothing. Forecasting based on smoothing, adaptive smoothing. 1.3 Time - series as a discrete parameter stochastic process. 1.4 Auto covariance and autocorrelation functions and their properties, Portmanteau tests for noise sequences, transformation to obtain Gaussian Series	
Unit II	**Stationary processes**	**15**
	2.1 General linear processes, moving average (MA), auto regressive (AR), and autoregressive moving average (ARMA). 2.2 Auto regressive integrated moving average (ARIMA) models, Box –Jenkins models Stationarity and inevitability conditions, 2.3 Non-stationary and seasonal time series models: Seasonal ARIMA (SARIMA) models, Transfer function models (Time series regression) , Concept of Causality, invertibility, computation of -weights and ψ-weights, computation of ACVF, ACF and PACF.	
Unit III	**Time series forecasting models**	**15**
	3.1 Durbin-Levinson algorithm, innovation algorithm (without proof). 3.2 Estimation of mean, auto covariance and autocorrelation functions, Yule- Walker estimation, Estimation of ARIMA model parameters, maximum likelihood method, large sample theory (without proofs). 3.3 Choice of AR and MA periods, FPE, AIC, BIC, residual analysis and diagnostic checking.	
Unit IV	**Multivariate Time series models**	**15**
	4.1 VAR models, Vector ARMA models. 4.2 Conditional heteroscedastic models, ARCH and GARCH, properties, examples, estimation & forecasting, extensions of ARCH and GARCH.	

Course Outcomes: Students should able to

1. Remove trend and seasonality using different methods to convert the time series into stationary.
2. Understand time series, auto-covariance, auto-correlation their properties, various smoothingtechniques.
3. Obtain Causality and inevitability, π -weights and ψ- weights, ACVF, ACF, PACF.
4. Understand estimation of ARIMA model, residual analysis and diagnostic checking, theirforecasting.

References:

1. George E. P. Box, Gwilym M. Jenkins, Gregory C. Reinsel, Greta M. Ljung, Time Series Analysis:Forecasting and Control (5th Edition, Wiley 2015)
2. P. J. Brockwell and R. A. Davis, Time Series: Theory and Methods (Springer ,1987)
3. R. S. Tsay, Analysis of Financial Time Series (3rd Ed, Wiley Series in Prob. and Statistics 2010)
4. M.G. Kendall, Time Series, (Charler Graffin,1978)
5. C. Chatfield ,The Analysis of Time Series - An Introduction (Sixth edition, Chapman and Hall,2004)
6. James D. Hamilton, Time Series Analysis (Princeton University Press, 1994)

MST 542: STOCHASTIC PROCESSES

Course Objectives: Student will able to

1. Learn and understand stochastic processes predictive approach.
2. Develop the ability to analyse and apply some basic stochastic processes for real life situations.
3. Study the distribution of first passage time, Long-run distribution, conditional joint distribution of interarrival times.
4. Understand different process and models.

Credits=4	**MST 542: STOCHASTIC PROCESSES**	**No. of hours: 60**
Unit I	**Stochastic process**	**15**
	1.1 Definition, Classification of Stochastic processes according to state space and time domain, Transition Probability Matrix, Markov chain, Examples of Markov Chain Formulation of Markov Chain models, initial distribution. 1.2 Chapman-Kolmogorov Equation, calculation of n-step transition probabilities, 1.3 Classification of States and Limiting Distributions.	
Unit II	**Theorem regarding Stochastic process**	15
	2.1 First entrance theorem, first passage time distribution, random walk model, Gambler's ruin problem. 2.2 Long-run distributions of Markov chain, relation with mean recurrence time, stationary distribution.	
Unit III	**Poisson Process and Queing Theory**	15
	3.1 Poisson process, distribution of inter arrival times, conditional joint distribution of inter arrival times, compound Poisson process, Some applications.	

	3.2 Introduction to the birth process, birth and death process, linear birth and death process, Expression for mean and variance of a birth process and, birth and death process, Applications of these processes. 3.3 Growth model with immigration and related results, Queueing systems, Markovian and non-Markovian queueing systems, embedded Markov chain applications to M/G/1.	
Unit IV	**Renewal Process and branching process**	**15**
	4.1 Renewal and delayed renewal processes, equilibrium (Stationary) renewal process, related theorems, key renewal theorem, Galton Watson Branching process(GWP) 4.2 Probability of ultimate extinction. the relationship between criticality parameter and extinction probability of the process, 4.3 Simulation of Markov Chain, Poisson process and branching process.	

Course Outcomes: Students should able to understand

1. The stochastic processes, Markov chain and Transition probability matrix, various types of statesand limiting distribution.
2. The random walk model, Gambler Ruin Problem and able to compute long run distribution ofMarkov chain.
3. Apply the Poisson process, Birth and Death process and various Queuing systems in real life.
4. The branching process and able to make simulation of Markov Chain, Poisson process and branchingprocess.

References:

1. *Medhi J.*, Stochastic Process (Wiley Eastern.,1982)
2. *Karlin & Taylor*, A First Course in Stochastic Process, Academic Press., Vol. -1 (Academic Press, NewYork, (1975)
3. *Cinlar E.* , Introduction to Stochastic Process, Prentice Hall, (1974)
4. *Sheldon M. R.*, Introduction to Probability Module, Eleventh Edition, Academic Press elsevier.com. (2014)
5. *William F.*, An Introduction to Probability Theory and Its Applications, Vol. 1, 3rd Edition.Wiley,(1968)
6. *Hoel P. , Port S., Stone C.,* Introduction to Stochastic Processes, Waveland Pr Inc. publisher (1972)

MST 543: ADVANCED OPTIMIZATION TECHNIQUES

Course Objectives: Student will able to

1. The basic components of optimization problem.
2. Understand formulation of problem as mathematical programming problem.
3. Concept of goal programming problem, inventory model, EOQ, replacement problem.
4. Learn advanced methods in operations research course that are used in the

systemsapproach to Engineering and Management.

Credits=4	MST 543: ADVANCED OPTIMIZATION TECHNIQUES	No. of hours: 60
Unit I	**Goal Programming**	**15**
	1.1 Meaning & Concept of GP, Difference between LP & GPApproach, Model Formulation, Graphical Method to Solve GP, Modified Simplex Method.	
Unit II	**Deterministic inventory models**	**15**
	2.1 The meaning of inventory control, factors involved in inventory problem, inventory model building, Concept of EOQ, **2.2 Single item inventory control models without shortages:** Model I (a): EOQ model with constant rate of demand. Model I (b): EOQ model with different rates of demand in different cycles. Model I (c): Economic lot size with finite Rate of replenishment. (EOQ production model) **2.3 Single item inventory control models with shortages:** Model II(a): EOQ model with constant demand and variable order cycle time, Model II(b): EOQ model with constant demand and fixed reorder cycle time, Model II (c): The production lot size model with shortages.	
Unit III	**Supply Chain Management (SCM)**	**15**
	3.1 Introduction: Defining SCM, Development Trends **3.2 Global SC Operations**: Global Business Environment, Strategic Challenges, Current change in Global SCM **3.3 Supply chain Design and Planning**: Supply chain configuration, Extent of vertical Integrations**,** Outsourcing and offshoring, Location Decision, Capacity Planning, Bullwhip effect	
Unit IV	**Replacement Problems**	**15**
	4.1 Types of failure: Gradual failure, Sudden failure **4.2 Replacement policy for items whose efficiency deteriorates with time:** whenvalue of money remains constant and when value of money changes **4.3 Replacement of items that completely fail:** Mortality tables, mortality theorem, individual and group replacement policy.	

Course Outcomes: Students should able to

1. Understand meaning of goal programming, distinguish between LP and GP.
2. Understand problem of inventory control, factor affecting on it, their model building andconcept of EOQ.
3. Understand application of inventory models.
4. Analyze replacement problem and various replacement policies, their applications inreal life.

References:

1. *Hadley G.* , Linear Programming (Addison Wesley.,1969)
2. *Taha H. A.,* Operation Research An Introduction (Macmillan,1971)
3. *Kanti S. & Gupta M. M.,* Operations Research (Sultan Chand & P. Gupta,1985)

4. *J. K. Sharma,* Operation Research Theory and Applications (Macmillan., 2003)
5. *Dawei L.*, Fundamental of Supply Chain Management (ebook bookboon.com, 2011)

MST 544: PLANNING AND ANALYSIS OF INDUSTRIALEXPERIMENTS

Course Objective: Student will able to

1. Develop the necessary skills of students to plan the experiments so that data obtained can beanalyzed to yield valid and objective conclusions.
2. Develop scientific view to analyze the industrial data about specific perspective.
3. Understand factorial experiments and concept of confounding.
4. Aware about simulation study and model building.

Credits=4	**MST 544: PLANNING AND ANALYSIS OF INDUSTRIALEXPERIMENTS**	**No. of hours: 60**
UNIT I	**2^k factorial Experiments**	15
	1.1 Basic concepts of design of experiment. 1.2 Methods to study Analyzing Design, Nested and Split Plot Design. 1.3 Concepts of main effects, interaction, their graphical representation, Analysis of full 2k replicated and un-replicated factorial designs. 1.4 Concept of Confounding: Total and partial confounding, construction and analysis confounded design.	
UNIT II	**3^k factorial Experiments**	**15**
	2.1 Concepts of main effects, interaction, their graphical representation, linear and quadratic components, Analysis of full 3^k replicated and un- replicated factorial designs. 2.2 Confounding: construction and analysis confounded design, Factorials with mixed levels.	
UNIT III	**Fractional Factorial**	**15**
	3.1 Fractional replication for symmetric factorials, concept ofgenerator, defining contrasts, aliasing, resolution and minimum aberration, construction and analysis of 2^{k-p} and 3^{k-p}fractional designs, Central composite designs.	
UNIT IV	**Response surface experiments**	**15**
	4.1 Linear and quadratic model, test for curvature, stationary point, central ridge systems, Rotatability, Multiple responses. 4.2 Taguchi methods: Concept of noise and control factors, inner and outer arrays, concept of loss function, S/N ratio, orthogonal arrays, linear graphs, interaction tables.	

Course Outcomes: Students should able to

1. Understand the basic concepts of design of experiments, concept of confounding.
2. Analyse different factorial and fractional experiments their interactions, graphical

representation andconfounding.

3. Understand fractional factorial design.
4. Apply simulation techniques.

References:

1. *D. C. Montgomery*, Design and Analysis of Experiments (8th edition, WileyIndia PvtLtd., 2013)
2. *O. L. Davies,F. J. van Dun En,H. C. Hamaker*, The design and analysis of industrial experiment,Oliver & Boyd, (1995)
3. *D. Voss and A.* Dean Design and Analysis of Experiments, Springer verlag Gmbh., (1999)
4. *C. F. Jeff Wu, Michael S. Hamada,* Experiments: Planning, Analysis and Parameter DesignOptimization, Wiley & Sons.,2nd edition, (2000)
5. *William G. Cochran, Gertrude M. Cox,* Experimental Design New York: John Wiley & Sons,(1959)

MST 544: ACTUARIAL STATISTICS

Course Objective: Student will able to

1. Develop the necessary skills of students to understand the insurance business and to design insurancepolicies.
2. Learn the life tables used in insurance products.
3. Learn the concept of interest, different life insurance products, life annuities, net premiums.
4. Motivate students to prepare for exams required for employment in the actuarial science profession.

Credits=4	**MST 544: ACTUARIAL STATISTICS**	**No. of hours: 60**
UNIT I	**Insurance Business and Future life time Distribution**	**15**
	1.1 Introduction to Insurance Business, Concept of risk, types of risk, characteristics of insurable risk. Risk models for Insurance: Individual and aggregate Risk models for short term, Distribution of aggregate claims, compound Poisson distribution and its applications. 1.2 Survival function and Life tables: Survival function, Distribution function, Density functions and Force of mortality. Time-until death random variable and Curate- future lifetime random variable.	
UNIT II	**Life Tables and Life Insurance Products**	**15**
	2.1 Life tables, Select and ultimate life tables. Assumptions for fractional ages and some analytical laws of mortality. 2.2 Life Insurance: Principles of compound interest: Nominaland effective rates of interest and force of interest and discount, compound interest, Insurance payable at the moment of death and at the end of the year of death ,Whole life insurance, endowment insurance, term insurance, deferred insurance and varying benefit insurance.	
UNIT III	**Annuities**	**15**
	3.1 Annuities: annuity certain, discrete annuity, monthly annuity, continuous annuity, deferred annuity, present values and accumulated values of these annuities 3.2 Continuous life annuity, discrete life annuity, such as whole life annuity,	

	temporary life annuity, n- year certain and life annuity, life annuities with mthly payments 3.3 Present value random variables for these annuity payments, their means and variances, Actuarial present value of the annuity.	
UNIT IV	**Reserves and Multiple Life Contracts**	**15**
	4.1 Concept of reserve, fully continuous reserve, fully discrete reserve. Prospective and retrospective reserve, Reserves on a semi continuous basis and true m-thly premiums. 4.2 Reserves on an apportionable or discounted continuous basis. Recursive formulates and differential equations for reserves commutation functions. **4.3 Multiple life functions**. Joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws.	

Course Outcomes: Students should able to

1. Understand the insurance business, concept of risk and claims.
2. Compute the life tables.
3. Compute various types of annuities.
4. Understand various principles to decide premiums

References:

1. *Deshmukh S. R.*, An Introduction to Actuarial Statistics, University Press., (2009)
2. *Robin C., Thomas N. Herzog, Richard L.*, Models for Quantifying Risk 4th Edition, ACTEX Publications, (2011)
3. *David C. M. Dickson, Mary R. Hardy and Howard R. Waters*, Actuarial Mathematics for lifecontingent risks International series on actuarial science, Cambridge (2009)
4. *Uma N.*, Insurance Industry in India: Features, Reforms and Outlook, Uma New CenturyPublications, (2013)

MSP 545: On Job Training (OJT) (4 Credits)

OJT will provide the opportunities for internship with local/regional industries, business organization, health and allied areas, local government, etc. so that students may actively engaged with the employability opportunities. Students will undergo 4 credit work based learning/OJT/internship.

MSP 546: PRACTICAL LAB-IV

Course Objective: Student will able to

1. Understand and implement theory in real life problems.
2. Apply operations research techniques to solve real life problems.
3. Apply different designs and time series techniques in real life situations.
4. Construction of t.p.m. and probability findings.

Credits=2	MSP 546: PRACTICAL LAB-IV	No. of hours: 60
	1. Goal Programming. 2. Deterministic inventory models I 3. Deterministic inventory models II 4. Replacement Problems 5. Optimization Problems 6. Realization of stochastic process. 7. Classification of Transition Probability Matrix and computation of n- step probability matrix. 8. Classification of states: Computations of absorption probabilities. 9. Stationary distribution and recurrence time. 10. Queuing Theory 11. Auto covariance 12. Autocorrelation. 13. Causal and Invertible 14. Smoothing the series 15. Forecasting 16. Construction of Life Tables. 17. Computations of benefit premiums at the moment of death 18. Computations of benefit premiums at the end of year of death 19. Computation of Annuities. 20. Computation of Reserve.	

Course Outcomes: Students should able to

1. Solve the problems of goal programming, inventory, replacement and DEA.
2. Do classification of t. p. m., state space and computation of probability matrix.
3. Recognize trend of data and use appropriate time series model.
4. Construction of life tables and computation of benefit premiums, annuities and reserve.

References:

1. *J. K. Sharma*, Operation Research Theory and Applications, Macmillan (2003)
2. *J. Medhi*, Stochastic Process, Wiley Eastern (1982)
3. *M.G. Kendall*, Time Series, Charler Graffin (1978)
4. *D. C. Montgomery*, Design and Analysis of Experiments (8^{th} edition), Wiley India Pvt Ltd. (2013)
5. *S. R. Deshmukh*, An Introduction to Actuarial Statistics, University Press (2009)